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Spaceplanes, Hypersonic Platforms and the Missile Technology Control Regime

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Summary

In Space launch systems, there is -- besides the well-known manned Space Shuttle of the United States – the ongoing development in the US, as also in India, of reusable unmanned space vehicles. The orbital-delivery components of these vehicles are designed to re-enter the atmosphere at hypersonic speeds, and to survive that re-entry, intact, for refurbishment and re-use. The technologies that enable such survival can be utilised for the development of hypersonic boost-glide platforms for ordnance-delivery. Such enabling technologies are characterised as being 'dual-useable'.

Besides the United States, Russia and China, other nations possessing the applicable enabling technologies are also experimenting with, or evaluating, hypersonic boost-glide platforms for precision-delivery of military ordnance – conventional or potentially nuclear.

India and other co-members of the Missile Technology Control Regime (MTCR), adopt a common approach to controlling the export from their territories of specified classes of missiles, and of missile-usable systems and technologies, so as to slow or stymie the development of missiles and Unmanned Ariel Vehicles (UAVs) by those countries which have to import critical technologies for the development of their own missiles or UAVs.

India shares missile non-proliferation objectives and responsibilities with other members of the MTCR. It is in India's foreign policy and geo-strategic interests to propose extension of MTCR to control over international trade in re-usable Space launch systems and their enabling dual-useable technologies. Specifically, India may propose to co-members inclusion of new entries in the MTCR Annex as detailed in the concluding section.

1. Introduction

After the content of this article was prepared in early September, 2017 in the format of what in diplomatic parlance is called a 'non-paper', a quite extensive**,** and elucidatory report appeared later that month from the US RAND Corporation.[2], which followed a Rand Commentary of a year earlier.[3]

Both the referenced Rand publications are explicit in providing the rationale for preventing HSW and their technologies from migrating to other countries – a process known as horizontal

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[2] Richard H.Speier, George Nacouzi, Carrie Lee, Richard Lee, Richard M. Moore, "Hypersonic Missile Non-Proliferation, Hindering the Spread of a New Class of Weapon System", https://www.rand.org/pubs/research_reports/RR2137.html

[3] Daniel M. Norton, "The Future of Hypersonic Weapons", https://www.rand.org/blog/2016/10/the-future-of-hypersonic-weapons.html , 20 October 2016

proliferation -- by sale or otherwise. Thus, the summarising blurb of the 2017 Rand report reads, in part:

"The diffusion of hypersonic technology is under way in Europe, Japan, Australia, and India — with other nations beginning to explore such technology. Proliferation could cross multiple borders if hypersonic technology is offered on world markets."

Some sparse information on the Indian effort on development of supersonic cruise missiles is publicly available. The effort is described authentically on the BrahMos website[4]; was revealed as a model displayed at the Aero India show held in February, 2017 in Bengaluru and continues to be speculatively commented on in aerospace magazines, as also on the web.

In assessments of work on hypersonics outside of the US, Russia and China, the September 2017 Rand Report adopts the by-now statutory 3D – disdainful, derisive and dismissive -- attitude to any Indian effort: "We note India's need for significant foreign technical assistance to develop its hypersonic programs", say the authors of the Report -- referencing a certain Purohit -- while yet warning of "possible export of BrahMos-II"!

So, it must come as no surprise that a think-tank report from the country-of-conception of the 'only-we-five' nuclear non-proliferation treaty (NPT) should advocate control over the acquisition of hypersonic technologies by countries "beyond the US, Russia and China" to (*sic*) "lesser nations" – a colonial attitude of technological superiority that was portrayed also in a barely-concealed racist *New York Times* September 28, 2014 cartoon when India, uniquely on a maiden attempt, successfully orbited her *Mangalyaan* spacecraft around Mars.

2. Precision counter-force conventional strike: Hypersonic platforms as enablers and the consequences of their use.

2.1 On hypersonic missiles

As with supersonic (speed greater than local speed of sound, that is Mach one), 'hypersonic' is also a classification of speed relative to the speed of sound in air at flight-height. But the Mach number that indexes 'hypersonic' is a matter of convention amongst aerodynamicists, and used by everybody else. Very broadly, it is the speed above which heating caused by aerodynamic friction begins to influence significantly the characteristics of the flow itself, i.e. at around Mach 5.

One way to classify carriers of ordnance is by the speed-of-arrival of the warhead on the target, rather than by the type of carrier (e.g. ballistic or cruise missile). Ajey Lele has provided a review of hypersonic weapons[5] using this classification, which can facilitate thinking about counter-measures.

As noted in the 2017 Rand report referenced, the primary reason why hypersonic glide vehicles and hypersonic cruise missiles are a new class of threat is because these delivery

[4] "Brahmos Hypersonic Cruise Missile", http://www.brahmos.com/content.php?id=27
[5] "Hypersonic Weapons", IDSA Occasional Paper No.46, July 2017, http://www.idsa.in/system/files/opaper/op_46_hypersonic_weapons-ajey-lele.pdf

platforms are capable both of manoeuvring and of flying faster than Mach 5. These two features – manoeuvrability combined with speed – enable hypersonic missiles to penetrate most missile defences -- further compressing the timelines for a response by a nation under attack. Sency Darren has reviewed and annotated the existing literature on the effects of these features on strategic stability.[6]

A demonstrated capability to affect precision conventional strike on adversary-advertised N-capable assets in potential battle-spaces may furnish a unique means to send a message of resolve. That is, message-by-demonstration in a way that obviates the inherent brinkmanship of conveying credibly the resolve to perform an otherwise incredible act; namely, to effect an N-strike -- a new, even if macabre, topic in the many varied logics of nuclear dissuasion and deterrence.[7]

The ability to effect counterforce strikes with precision and reliability on nuclear-capable weapons carriers in the conventional battle-space, and the consequences of acquiring this capability on deterrence concepts and doctrines, are explored in "Stalking the Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy".[8]

Further discussion here on the merits or otherwise of doctrines of readiness for and consequences of hypersonic precision, conventional counter-force strike is outside the scope of this contribution but for elucidations, see Nagappa, Rajaram's, " New technology, familiar risks"[9], and extensive discussions at the EU Non-Proliferation and Disarmament Conference 2015, Brussels, November 11-12, 2015.[10]

2.2 On hypersonic gliders

There have been two notable developments in these potential weapons-delivery platforms. The first is the testing by China and Russia of unpowered gliders that are designed and configured to fly and manoeuvre at hypersonic speeds at military-aircraft heights so as to enable evasion of anti-aircraft missile defences. For a descriptive elaboration of these developments in all three countries, see *Chinese Hypersonic Weapons*.[11] The rest of this article is primarily on the dual-use hypersonic glide capability of Spaceplanes: It is not about hypersonic cruise missiles powered to near-target by scramjets, nor about purpose-designed gliders for hypersonic conventional strike.

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[6] "Hypersonic Weapons' Effect on Strategic Stability", *Space & Defense*, Vol.10, No.1, Spring 2017, Journal of the United States Air Force Academy, Eisenhower Center for Space and Defense Studies.

[7] Sethi, Manpreet, "The dangers of accepting nuclear brinkmanship as the new normal", http://capsindia.org/files/documents/CAPS_ExpertView_MS_02.pdf , 06 October 2017

[8] Austin Long and Brendan Rittenhouse Green "Stalking the Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy", The Journal of Strategic Studies, 2015 Vol. 38, Nos. 1–2, 38–73

[9] Nagappa, Rajaram, " New technology, familiar risks", http://thebulletin.org/test-ban-hypersonic-missiles/new-technology-familiar-risks , 25 June 2015

[10] Rajaram Nagappa, "Advances in Missile Delivery Systems", http://isssp.in/advances-in-missile-delivery-systems/ , audios accessed on 13 September, 2017

[11] Erika Solem, Karen Montague, "Chinese Hypersonic Weapons " Development,https://jamestown.org/program/updated-chinese-hypersonic-weapons-development/, accessed on 13 September, 2017

3. Developments in space launch systems with re-use features.

The literature on the historical trajectory of the development of transportation systems for delivery of payloads to near-Earth space is replete with lamentation of the missile/launch-vehicle dual-use legacy-burden borne by expendable space launch vehicles -- as distinct from reusables**.** Thus, as early as April 1957 "the US Air Force had combined its previous boost-glide hypersonic studies into a single development plan that envisaged a highly manoeuvrable delta-wing vehicle boosted to a low-Earth orbital glide path before reentering the atmosphere and landing at a conventional airfield" [See Note 4, Epilogue, To Reach the High Frontier: A History of U.S. Launch Vehicles edited by Roger D. Launius and Dennis R. Jenkins, University Press of Kentucky, 2014].

But the panic in the US following the launch in 1957 of Sputnik by the Soviet Union derailed this, and many other, development plans for reusables, both civilian and military.

No coincidence either that the creation of the MTCR in April 1987 followed a month after the first launch of India's all-solid Augmented Satellite Launch Vehicle (ASLV).

While the demonstrator re-usable 'Dream Chaser' spaceplane, has been flight-tested,[12] the first really new development in un-crewed civil space launch systems we should expect -- particularly following the entry of the private sector into providing launch services -- is the advent of Assisted Launch, and Two-Stage-To-Orbit (TSTO) systems, with a true, reusable, un-crewed payload-delivery stage.[13] The prospect is realistic of a new generation of space vehicles capable of economically delivering small payloads coming on line well before the end of this decade. These vehicles are expected to revolutionize space access by providing frequent, low-cost access to space.[14]

The second development we should expect is the use of hypersonic air-breathing propulsion systems to achieve the required orbital velocities for the lowest cost-per-kilogram delivered at the time customers want access to their desired orbit.[15]

4. Indian developments towards reusable Spaceplanes.

It bears re-iteration that *Spaceplanes* (with air-breathing/Scramjet, or some use of the atmosphere -- e.g. LoX-making on-board) are very different in concept, design, flight-profile and performance from re-useable/re-furbishable *rockets* -- *a la* the US Space shuttle.

In India, conceptual studies and designs for 'Spaceplanes' have been on-going since the about CE 2000.[16] In around 2005 Sivathanu Pillai, then CEO of Brahmos (the Indo-Russian joint-venture

[12] "Dream Chaser completes successful glide test" ,*Spaceflight Insider*, November 14, 2017 http://www.spaceflightinsider.com/organizations/sierra-nevada/dream-chaser-completes-successful-glide-test/

[13] "A Study of ARTS: A Dual-Fuel Reusable Launch Vehicle with Launch Assist", http://www.sei.aero/archive/AIAA-2003-5269_present.pdf , Joint Propulsion Conference , Huntsville, Alabama, July 2003

[14] Next-Generation Suborbital Researchers Conference, http://www.boulder.swri.edu/NSRC2017/Site4/Purpose.html , December 18-20 2017

[15] Karl Hoose, "Hypersonic Air breathing Propulsion: The Key to affordable nanosatellite Launch", http://www.thespacereview.com/article/3315/1 , 28 August 2017

Company), requested Raghavan Gopalswami to present the concept of the scramjet-powered '*Avatar* flight technology demonstrator' concept to a Brahmos team. The Russians improved on the concept, and made it relevant for their (Russian) hypersonic anti-shipping missile Zircon. (The irony will not be lost on the reader of *Zircon* as a platform being unavailable to India!).

In December, 2014, as part of its programme of developing enabling technologies for human space flight, India's Space agency (ISRO) retrieved intact from the sea an experimental 'crew module' which had been guided for hypersonic descent after a sub-orbital flight prior to parachute deployment.[17]

The agency conducted a flight test in May 2016 of a scaled version of its experimental reusable launcher.[18] For a popular media feature on that development see "*Making of India's Space Shuttle – The Inside Story*".[19] On August of the same year, ISRO conducted a successful flight-test of an experimental scramjet.[20]

And so we come full circle: Hypersonic ordnance delivery and reusable carriers of space-payloads have brought back the dual-use characteristic of space launch systems.

5. MTCR – what it is *not* about

The formation of the nuclear export control regime -- the Nuclear Suppliers Group (NSG) – followed soon after India's first nuclear test in 1974. Likewise, the regime to control international trade in missile-useable technologies – the Missile Technology Control Regime (MTCR) -- was triggered by India's self-development of Space Launch Vehicles. MTCR followed a month after the first launch in March 1987 of ISRO's all-solid Augmented Satellite Launch Vehicle (ASLV). The move in June 1982 of APJ Abdul Kalam, the project director of ISRO's first satellite launch vehicle, SLV-3, to the directorship of Defence Research and Development Laboratory -- India's missile laboratory in Hyderabad -- had been earlier commented on in much more than 'brief mentions' in the specialised aerospace magazines of the West.

The MTCR is a missile technology *export* control regime. It does not deny the self-development by countries of missiles, but does seek to hamper, stymie the pace of, and restrict to only small payloads and short ranges, such missiles as may be self-developed. Members of the regime accomplish this end by collectively controlling international trade in technologies that can be used in the development of either of Space launch vehicles or of ballistic missiles – hence the 'dual-use' appellation. That is why MTCR is an instrument to slow, if not prevent, the horizontal proliferation of missiles. It is not, in and of itself, an instrument of arms control.

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16 Raghavan Gopalswami and others, Design Patent D 477,806 of July 29, 2003, filed in the US on encouragement by APJ Abdul Kalam

17 "First Experimental Flight of India's Next generation Launch Vehicle GSLV Mk-III Successful", http://www.isro.gov.in/update/18-dec-2014/first-experimental-flight-of-indias-next-generation-launch-vehicle-gslv-mk-iii , 18 December 2014

18 "RLV-TD", http://www.isro.gov.in/launcher/rlv-td, 23 May 2016

19 "Making of India's Space Shuttle – The Inside Story", http://www.ndtv.com/india-news/exclusive-making-of-indias-space-shuttle-the-inside-story-1408551 , 23 May 2016

20 "Successful Flight Testing of ISRO's Scramjet Engine Technology Demonstrator*",* *http://www.isro.gov.in/update/28-aug-2016/successful-flight-testing-of-isros-scramjet-engine-technology-demonstrator* *, 28 August 2016*

A great deal has been written on the effectiveness of MTCR in achieving its objectives. While all that expatiation will not be rehearsed here, for the best assessment of the impact of that regime on India's space and missile programmes, see: Bhaskaran, A. Export Control Regimes and India's Space and Missile Programmes, *India Quarterly*, Vol.58, Issue 3-4, 2002.

It is in India's interest to stymie the self-development by other countries of hypersonic platforms. With increasing involvement on a substantial scale of industrial enterprises, particularly in the private sector – including those with foreign private equity -- in our Space and missile programmes, India needs to ensure that no export or re-export occurs from India of parts, components, sub-systems or technology, that can contribute to or assist such self-development of hypersonic platforms by other countries.

6. Conclusion

Amendments to the MTCR Annex as proposed below will not in any way oblige us, as members of MTCR, to constrain our own development of hypersonic platforms or Spaceplanes. They will facilitate greater involvement of the private sector – including those with foreign equity – in such development, while not giving any quarter to the sullying of our excellent non-proliferation record.

We can then sit back and await another RAND Report whose title reads:

"US, Russia, India cooperation could stymie the proliferation of hypersonic platforms for ordnance delivery, while furthering lower cost of access to Space"!

Proposed Amendments to MTCR Annex

In practical terms, India may propose as a member of MTCR that the MTCR Annex (Cf. MTCR/TEM/2017/Annex of 18th May 2017) be amended, *inter alia*, in the following sample manner:

Add to: Definitions (even though "Missiles" are not defined in the referenced Annex, and the proposed definitions below do deviate from that norm):

2C: "Lifting Bodies" or "Hypersonic Gliders" are vehicles capable of return to land or water. After traversing the atmosphere from space at speeds of Mach 5 or more, and capable of refurbishment for reuse after such return.

Add to: Category 1, Item 1

1.A.3. Complete "Lifting Bodies" or "Hypersonic Gliders" capable of return to land or water after traversing the atmosphere at Mach 5[?] or more, and capable of accommodating any payload of weight greater than [TBD] Kg.

Add to: 2.A.1

C. Equipment, sub-systems and components usable in the systems specified in 1.A.3, and, as follows

1. Heat shields, whether or not integral with the “Lifting Body” or “Hypersonic Glider”, and components therefor, fabricated of ceramic or ablative materials;

2. Fins for control of vehicle aerodynamics and components therefor, fabricated in part or whole of ceramic or ablative materials;

3. Electronic, control or actuating equipment designed to control and manipulate during re-entry (1) or (2) above.

Add as (new) Category 2.F. *“Special arrangements for transfer for launch of “Lifting Bodies” and “Hypersonic Gliders”*

“For the transfer of a “lifting Body” or “Hypersonic Glider” for launch from a territory in the legal jurisdiction of a non-adherent to MTCR, suppliers shall: (1) not transfer any enabling design or manufacturing technology associated with such launch activity; and (2) seek from the launching State an appropriate agreement to accept the “Lifting Body” or Hypersonic Glider” under conditions that do not permit or enable their replication, or of the launch-support and ground-handling equipment for them.”

Note: “Launching State” shall be as defined in the ‘Convention on International Liability for Damage Caused by Space Objects, (UNGA resolution 2777 (XXVI)

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